CLAIMS

1. A method for segmentation of a digital picture consisting of a multiplicity of single picture elements comprising the following steps:

(a) determining if one of one and several features relating to contiguous picture objects comprising picture elements and picture segments are conforming or not conforming based on a specific homogeneity criterion by means of referencing a predetermined tolerance for each feature as a termination criterion, within which feature values relating to the contiguous picture objects in question may differ;

(b) if one of one feature and several features relating to the contiguous picture objects are determined to be conforming then merging the conforming picture objects; and

(c) repeating the resulting segmentation until the resulting segmentation converges in a stable or approximately stable condition in which no further contiguous picture objects are determined to be conforming.

2. The method of claim 1, wherein a feature difference to be compared in the homogeneity criterion is determined via heterogeneity introduced by merging two picture objects by determining a difference Δh_W between heterogeneities of respective picture objects weighted with the size of the respective picture objects after and before merging so that homogeneity is expressed by the formula

$$\Delta h_W = (n_1 + n_2)h_{new} - (n_1 h_1 + n_2 h_2) < \alpha$$

wherein α is the predetermined tolerance, h_1 and h_2 are heterogeneities of the respective picture objects, n_1 and n_2 are sizes of the respective picture

objects and h_{new} is the heterogeneity of a potentially newly formed picture object.

3. The method of claim 2, wherein the heterogeneity of the potentially newly formed picture object is defined as standard deviation of color mean values of the respective picture objects as expressed by the formula

$\Delta h_W = \Delta\sigma_W = (n_1 + n_2)\sigma_{new} - (n_1\sigma_1 + n_2\sigma_2) < \alpha$

wherein σ_1 and σ_2 are standard deviations of the respective picture objects and σ_{new} is the standard deviation of the potentially newly formed picture object.

4. The method of claim 3, wherein a predetermined value for the standard deviation is used for small picture objects having a size of approximately one to five picture elements.

5. The method of claim 2, wherein the heterogeneity of the potentially newly formed picture object is defined as the variance of color mean values of the respective picture objects as expressed by the formula

$\Delta h_W = \Delta var_W = (n_1 + n_2)var_{new} - (n_1 var_1 + n_2 var_2) < \alpha$

wherein var_1 and var_2 are variances of the respective picture objects and var_{new} is the variance of the potentially newly formed picture object.

6. The method of claim 2, wherein the heterogeneity of a potentially newly formed picture object is determined via a weighted difference of color mean values of the respective picture objects before and after merging as expressed by the formula

$\Delta h_W = \Delta m_W = (n_1 + n_2)|m_{new}| - (n_1|m_1| + n_2|m_2|) < \alpha$

wherein m_1 and m_2 are color mean values of the respective picture objects and m_{new} is the color mean value of the potentially newly formed picture object.

7. The method of claim 2, wherein picture regions having continuous color transitions are combined and the heterogeneity of the potentially newly formed picture object is defined as one of the average distance and the average value of the squares of the distances of the color mean values of the respective picture objects depending on the dimensionality of the topical space in relation to a regression line, surface or hypersurface of the color mean values in the topical space or in relation to another function of approximation to the color mean values in the topical space.

8. The method of claim 1, wherein after step (c) the following steps are performed:

(d) determining if a new tolerance is selected; and

(e) if a new tolerance is selected then repeating the method for segmentation and returning to step (a) to thereby form a hierarchical structure of picture objects having different hierarchy planes.

9. The method of claim 8, wherein on a lowest hierarchy plane of the hierarchical structure picture elements are located, which are then at least on a next higher hierarchy plane of the hierarchical structure merged into over-picture objects, which may in turn be merged once or several times into over-picture objects on higher hierarchy planes of the hierarchical structure.

10. The method of claim 9, wherein the highest hierarchy plane of the hierarchical structure contains only one picture object.

11. The method of claim 8, wherein a new hierarchy plane is introduced in the hierarchical structure by initially duplicating all picture objects on a next lower hierarchy plane and inserting these picture objects in the new hierarchy plane as respective over-picture objects of the picture objects on the next lower hierarchy plane, wherein the picture objects on the new hierarchy plane which are determined to be conforming are merged in such a manner that only picture objects are merged which do not have different over-picture objects on a next higher hierarchy plane.

12. The method of claim 8, wherein an order in which picture objects of a plane are processed is an order which ensures a maximum possible distance from already processed picture objects and is a pseudo-stochastic order wherein in multiple, repeated runs on a hierarchical plane within one run each picture object present at the beginning of the run is processed once at the most by merging.

13. The method of claim 1, further comprising the following steps:

(f) determining if one of one and several features of already merged picture objects are still conforming or not still conforming based on the specific homogeneity criterion; and

(g) if one of one feature and several features of the already merged picture objects are determined not to be still conforming then excluding the not still conforming picture objects.

14. The method of claim 13, wherein steps (f) and (g) are performed in addition to steps (a) and (b) in an arbitrary order or in parallel.

15. The method of claim 13, further comprising the following steps:

(h) determining if a boundary picture object of already merged picture objects located at a boundary of the already merged picture objects satisfies the homogeneity criterion with the already merged picture objects as well as with one of one and several contiguous picture objects; and

(i) if the homogeneity criterion is satisfied with the already merged picture objects as well as with the one of one and several contiguous picture objects, allocating the boundary picture object to the picture object with which the homogeneity criterion is satisfied best.

16. The method of claim 15, wherein steps (h) and (i) are performed in addition to at least one of steps (a) and (b) and steps (f) and (g) in an arbitrary order or in parallel.

17. The method of claim 15, wherein if the homogeneity criterion is satisfied with the already merged picture objects as well as with the one of one and several contiguous picture objects, feature distributions of the already merged picture objects and the one of one and several contiguous picture objects are calculated and based thereon, a pertinence of the boundary picture object is determined in such a manner that the boundary picture object is allocated to the one picture object wherein a feature value of the boundary picture object occurs most frequently or that the boundary picture object is allocated to a picture object in a probabilistic manner by calculating probabilities based on a frequency of occurrence of the feature value of the boundary picture object in the already merged picture objects and the one of one and several contiguous picture objects.

18. The method of claim 17, wherein for the feature distributions respective histograms of the features of the already merged picture objects and

the one of one and several contiguous picture objects are referred to.

19. The method of claim 15, wherein, if a boundary picture object is re-grouped from one picture object into another picture object, coherence of the one picture object is examined and in case of non-coherence of the one picture object the one picture object is divided into corresponding coherent picture objects formed by re-grouping.

20. The method of claim 15, wherein the digital picture comprises a plurality of single channels having a different information content and boundary picture objects are regrouped from one picture object into another picture object only if the pertinence to the other picture object averaged through all single channels is greater than the pertinence to the one picture object averaged through all single channels.

21. The method of claim 15, wherein in merging or boundary correction object-related various homogeneity criteria are employed in accordance with specific features of the picture objects comprising compactness, size, boundary roughness, linearity, gradient of color development, and their classification.

22. The method of claim 1, wherein merging is performed only if a feature difference defined in the homogeneity criterion for one of the picture objects is smallest in comparison with the contiguous picture objects and contained within the predetermined tolerance.

23. The method of claim 1, wherein merging is performed only if for two picture objects a feature difference defined in the homogeneity criterion is smallest in comparison with the other contiguous picture objects and is

contained within the predetermined tolerance.

24. The method of claim 1, wherein merging is performed only if a feature difference defined in the homogeneity criterion is smallest in comparison with all other possible combinations of picture objects and is contained within the predetermined tolerance.

25. The method of claim 1, wherein picture objects are processed in a pseudo-stochastic order.

26. The method of claim 1, wherein picture objects are processed in an order which ensures maximal possible distance from already processed picture objects.

27. The method of claim 1, wherein several picture objects are processed simultaneously.

28. The method of claim 1, wherein the digital picture comprises a plurality of single channels having a different information content and picture objects are combined only if the homogeneity criterion referred to is satisfied for each one of the channels.

29. The method of claim 1, wherein the digital picture comprises a plurality of single channels having a different information content and wherein for the homogeneity criterion standard deviations, variances or mean values of color values of picture objects are added up or averaged through all channels, wherein the channels may be weighted differently.

30. The method of claim 1, wherein boundary picture objects are not referred to for determination of properties of large picture objects.

31. The method of claim 1, wherein the homogeneity criterion comprises texture features.

32. The method of claim 1, wherein a segmentation of lines is performed in which a value of linearity indicating a ratio of length and width of a picture object is used as a shape feature and picture objects are initially segmented such that each picture object exceeding a threshold for the value of linearity is processed as a line object.

33. The method of claim 32, wherein processing of a picture object as a line object comprises the following steps:

searching for picture objects matching picture objects complementing a line in a direction of line ends beyond an immediate vicinity as far as a specific distance and in a sector having a specific angle;

determining a factor which improves a matching value determined in the homogeneity criterion depending on how well a line is complemented by a previous line object, so that in case of an identical matching value linear combination is preferred to the usual combination;

determining criteria for how well a line is complemented, such as an improvement of the linearity of the previous line object, in addition to at least one of identical color contrast with the surroundings and identical color; and

establishing a connection having a minimum possible thickness between non-contiguous picture objects such that the line object is in any case diagonally coherent, if a matching picture object is not found in the immediate vicinity.

34. The method according to claim 32, wherein upon additionally performing linear segmentation, segmentation is initially performed with

diagonal vicinity, wherein small and linear picture objects have diagonal coherence and all other picture objects have planar coherence, wherein, if a hitherto small, diagonally picture object exceeds a critical size or if a hitherto linear picture object drops below a critical linearity by area merging, it is divided into its components having planar coherence.

35. A method for segmentation of a digital picture consisting of a multiplicity of single picture elements comprising the following steps:

(a) determining if one of one and several features relating to contiguous picture objects comprising picture elements and picture segments are conforming or not conforming based on a specific homogeneity criterion by means of determining a modification of the contiguous picture objects in question as a continuation criterion which leads to a minimum increase in a defined value for the complexity of an entire structure consisting of all picture objects;

(b) if one of one feature and several features relating to the contiguous picture objects are determined to be conforming then combining the conforming picture objects; and

(c) repeating the resulting segmentation until the resulting segmentation converges in a stable or approximately stable condition in which no further contiguous picture objects are determined to be conforming.

36. The method of claim 35, wherein by means of repeating the resulting segmentation a hierarchical structure is formed having several hierarchical planes which are present in a locally different hierarchical depth.

37. The method of claim 36, wherein a highest hierarchical plane consists of a single picture object containing all picture elements.

38. The method of claim 36, wherein respective modifications are performed on respective highest local hierarchical planes of the hierarchical structure.

39. The method of claim 38, wherein the modifications comprise at least one of merging two contiguous picture objects, exclusion of a picture object from another picture object, allocating a boundary picture object located at the boundary of already merged picture objects to another contiguous picture object and founding a new picture object on a next higher local hierarchical plane to be formed.

40. The method of claim 36, wherein the defined value for the complexity is defined as one of the sum through all picture objects in the hierarchical structure of standard deviations of color mean values of objects multiplied by the number of picture objects on a next lower hierarchical plane in each picture object

$$C = {}_{i}\ \sigma_{Udir}\ n_{i_{Udir}}$$

wherein C is the defined value for the complexity, σ_{iUdir} is the standard deviation of the color mean value of a respective picture object i, and n_{iUdir} is the number of the picture objects on the next lower hierarchical plane in each picture object, and

the sum through all picture objects in the hierarchical structure of variances of color mean values of the picture objects on the next lower hierarchical plane in each picture object multiplied by the number of picture objects on the next lower hierarchical plane in each picture object

$$C = {}_{i}\ var_{Udir}\ n_{i_{Udir}}$$

wherein C is the defined value for the complexity, var_{iUdir} is the variance of the color mean value of a respective picture object i, and n_{iUdir} is the number of the picture objects on the next lower hierarchical plane in each picture object.